The pH Scale — Answer Key

Sample answers. Accept other answers that use correct reasoning.

Part A · Read the Scale

1. Black coffee **A** (5.0) · Ammonia **B** (11.5) · Pure water **N** (7.0) · Seawater **B** (8.1) · Tomato juice **A** (4.2) · Bleach **B** (12.6)
2. **Orange juice.** Its pH (about 3.5) is lower than milk's (about 6.6), so it has more H^+: about 3 steps, or roughly 1,000 times more.
3. **Slightly basic.** 7.35–7.45 is just above 7, which is neutral.
4. **Disagree.** The farther a substance is from 7 in *either* direction, the more harmful it can be. Strong bases such as bleach (12.6) and drain cleaner (13.8) can burn skin and eyes, just like strong acids.

Part B · The Power of Ten

5. pH 3 vs. 6: **3 steps, 1,000×**
   pH 2 vs. 7: **5 steps, 100,000×**
   pH 4 vs. 8: **4 steps, 10,000×**
6. **10 times** — 5.6 to 4.6 is one step.
7. The scale counts by tens, so pH 2 has **10 × 10 = 100 times** more H^+ than pH 4. A small difference in the pH number is a big difference in acidity.

Part C · Indicators

8. **A: acidic, below 6.0** — e.g., vinegar, lemon juice, orange juice, tomato juice, black coffee.
   B: basic, above 8.2 — e.g., baking soda, milk of magnesia, ammonia.
   C: neutral, 6.0–7.6 (about 7) — pure water. (Milk or blood fit the bromothymol blue range; accept with reasoning.)
   D: slightly basic, 7.6–8.2 — seawater (8.1). Baking soda (8.3) would turn phenolphthalein pink.
9. Bromothymol blue shows the pH is **above 7.6**; phenolphthalein shows it is **below 8.2**. Each indicator changes color at only one point, so combining them narrows the pH to a small range.

Part D · pH in the Real World

10. The antacid is a **base**. It **neutralizes** some of the stomach acid (acid + base → salt + water), raising the pH so there is less acid to irritate the esophagus.
11. (a) **Yes** — 8.1 is still above 7. (b) The pH is **moving toward the acidic end**; H^+ has gone up by about 25–30% ($10^{0.1} \approx 1.26$). The name describes the direction of change. (c) Examples: shells and coral skeletons get thinner or dissolve; shellfish, corals, and plankton struggle to grow, which affects the animals that eat them.
12. **More acidic**; the pH number should **go down**.

Part E · Challenge

13. pH 1: **10^{-1} = 0.1** · pH **5**: **0.00001** · pH 7: **10^{-7} = 0.0000001**
14. Water spreads the H^+ ions out (dilutes them), so the pH **rises toward 7**. It **cannot go above 7**: water is neutral, so adding it only brings the mixture closer to neutral; it never makes it basic.
15. Sample: pH tells how acidic or basic a liquid is. Low numbers are acidic, 7 is neutral, high numbers are basic, and each step is 10 times stronger.